Chapter 5:
Promoting Infrastructure for Delivery and Distribution of Biofuels

Seizing the opportunity to make Massachusetts a national leader in the development and use of advanced biofuels will require improvement of infrastructure for biofuels delivery and distribution. In order to make biofuels a true alternative to petroleum products, consumers must be able to use them in their vehicles, homes and businesses. For advanced biofuels to transition successfully into a significant industry in the region, accommodations will be needed in the mechanisms by which Massachusetts meets its fuel needs. At present, such mechanisms in transportation, heating, and other uses are geared almost exclusively to the use of petroleum products and corn-based ethanol.

In 2006, Massachusetts accounted for about 2% (2.7 billion gallons) of the U.S. demand for gasoline (138 billion gallons), and 41% of New England's total gasoline demand (6.5 billion gallons).[1] Massachusetts is one of five states that use federal reformulated gasoline statewide, using a 10% ethanol blend (E10), which recently replaced the additive MTBE. This relatively low blend of ethanol adds to the oxygen content of gasoline, allowing it to burn more cleanly and reducing carbon monoxide and ground-level ozone emissions.

Diesel fuel is primarily used in the transportation sector, comprising about 89% of the 443 million gallons consumed in Massachusetts in 2006.[2] On-road diesel fuel must meet EPA's ultra low sulfur standards of not more that 15 parts per million sulfur. Since sulfur compounds serve a lubricating function in diesel fuels, ultra low sulfur diesel requires lubrication additives. Biodiesel and other biofuels in low blends could be added to diesel fuel as a premium lubricant, but are not yet in widespread use for this purpose.

Massachusetts consumed 638 million gallons of Number 2 heating oil in 2006. Residential customers, representing 39% of households in Massachusetts, accounted for 83% of this use. Commercial and industrial customers and some electric generators used the remainder. There are 600 to 800 heating oil dealers in Massachusetts, most of whom own their own delivery equipment and vehicles. Yet, there are relatively few heating oil suppliers in New England.

In the refining process, crude oil is heated until much of it becomes a gas, which when cooled condenses back to liquid form and, in the process, separates primarily into gasoline and distillate fuel oils, including diesel graded from 1 to 3. The heavy remaining oil is classified as Number 5 or, more commonly, Number 6 oil, and is also referred to as residual oil. The heaviest solids are used as lubricants, waxes, or asphalt.

Distillate fuels are used primarily for space heating (heating oil) and on- and off-highway diesel engine fuel (e.g. railroad engine fuel and fuel for agricultural machinery) and for electric power generation. Distillate fuel oil used by electric generators represents only about 1% of the total distillate fuel used. However, electric generators in 2006 accounted for about 63% of state use of the heavier Number 6 residual oil.

While ethanol and biodiesel are both used almost exclusively in blends with petroleum, their supply chain and infrastructure needs differ significantly. Seizing the opportunity to make Massachusetts a national leader in the development and use of advanced biofuels will require improvement of infrastructure for biofuels delivery and distribution.

Number 4 oil, which is generally made by blending Number 2 distillate oil with Number 6 residual oil, is used primarily in industrial plants and commercial burners; this includes No. 4 diesel fuel, which is used for low- and medium-speed stationary boilers. Some have proposed substituting biodiesel for Number 2 oil to create "Bio Number 4."[3] Residual oil is used for production of electric power, industrial processes, and for marine vessel fuel.

Petroleum Supply and Distribution

Like the rest of New England, Massachusetts lacks crude oil production, refining capacity, and direct service by a major interstate petroleum pipeline. All petroleum products are imported from two main sources: domestic refined products, originating in the Gulf Coast, and imports supplied primarily by Canada, Venezuela, and the U.S. Virgin Islands.

Most of these products arrive in Massachusetts by marine shipments. Up to 90% of petroleum used here is imported via ship or barge. Several major ports—including Boston, Braintree, Weymouth, Quincy, and Fall River—receive and store petroleum products. The remaining 10% enters Western Massachusetts, most of it by petroleum pipeline or truck. One small product pipeline (owned by ExxonMobil) runs from the port of Providence to Springfield terminals and another (owned by Buckeye Partners) carries only distillate fuels and jet fuel from the port of New Haven into the Springfield area. Western Massachusetts also receives petroleum products by truck from New York and heavy residual oils by rail.

There are 13 major terminals and several smaller bulk terminals in Massachusetts, in addition to regional terminals in neighboring states, that distribute refined petroleum products—ranging from jet fuel to gasoline to home heating oil—to customers in the Commonwealth. Various terminals are equipped for the storage and distribution of different types of refined products. Regional terminals are equipped with specialized loading stations (or racks) that load refined products into tanker trucks for distribution to end users, such as retail gasoline stations, or individual homes, in the case of home heating oil.

Petroleum products move from storage terminals primarily by road. Tanker trucks that deliver gasoline and diesel fuel to retail stations often have several separate compartments, allowing trucks to carry different formulations of fuel (e.g., regular unleaded, premium unleaded, and diesel) to retail stations in a single trip. In the case of gasoline, the ethanol or special additives that are used to differentiate one brand from another are often blended into the gasoline in the tank of the delivery truck as it is loaded at a terminal. In some cases, fuel blend components are picked up at multiple

Table 5.1: Overview of Massachusetts Petroleum Demand

Population	6,437,193 (2006)
Total Energy Consumption	1.5 quadrillion Btu (2004)
Per Capita Energy Consumption	240 million Btu (2004)
Total Petroleum Consumption	5.7 billion gallons per year (2005)
Gasoline Consumption	2.7 billion gallons per year (2006)
Gasoline Stations	2,700 outlets (2006) or 1.6% of U.S. total
Distillate Fuel Consumption	1.33 billion gallons per year (2006)
Heating Oil Consumption	638 million gallons per year (2006)
On-road Diesel Consumption	393 million gallons per year (2006)
Off-road Diesel Consumption	49 million gallons per year (2006)

Source: Energy Information Administration, U.S. Department of Energy; U.S. Census Bureau terminals and rely on "splash-blending" in the truck en route to delivery. This approach is typical of biodiesel blends, as well as other additives that are mixed into diesel fuel and home heating oil.

Home heating oil is transported by either a tanker truck or a smaller truck, called a bobtail, that typically holds up to 3,000 gallons and delivers the product to homes. Homes, which have heating oil tanks as small as 250 gallons, are supplied on "milk runs" that generally cover a service area of no more than 35 to 60 miles.

Biofuels Transportation and Storage

While ethanol and biodiesel are both used almost exclusively in blends with petroleum, their supply chain and infrastructure needs differ significantly. Properties of both ethanol and biodiesel prevent them from being distributed by pipeline in unblended form. Ethanol is easily contaminated by water, and biodiesel picks up and dissolves residues deposited in the pipelines by other fuels.

As a result, ethanol is primarily transported by barge, but also by railcar and truck, to large regional petroleum terminals. In smaller volumes, pure biodiesel (B100) comes to small inland terminals in Massachusetts, mainly by railcar and truck. In the near future, larger amounts of biodiesel may come into the major terminals by barge, or potentially by pipeline in low blends, such as B5.

Terminals are mainly comprised of massive tanks, each one dedicated to a particular refined petroleum product. Switching tanks from one fuel use to another can be complicated. For example, gasoline tanks require a system to recover vapor and return it to a liquid state, while tanks for home heating oil do not. In some cases, switching or upgrading tanks may require approval from regulatory authorities. Newer, stainless steel tanks can usually accommodate any petroleum product, while older tanks may have higher switching costs.

High blends of biodiesel require heating and insulation in winter to avoid the risk of the fuel gelling. The temperature at which liquid fuels gel (cloud-point temperature) varies by biodiesel feedstock and blend. This adds a significant retrofit cost to existing tanks or, more typically, requires terminals to add new purpose-built tanks. The costs of adding or retrofitting B100 biodiesel storage and inline blending equipment are currently unclear as estimates vary by terminal and range from $100,000 to over $1 million. In the absence of this equipment, one potential alternative is to blend in the tank by taking delivery of B100 biodiesel and the petroleum base fuel at the same time. This presents some logistical challenges and limits the terminal to offering only one blend per fuel type.

The Pioneer Valley Railroad, working closely with the City of Holyoke and other partners, is actively pursuing development of an existing storage and transfer site to create a regional inland terminal to supply biodiesel to Western Massachusetts and the surrounding region. This terminal would utilize the railroad spur from Westfield to Holyoke, providing rail access from multiple feedstock suppliers to serve power generation and heating oil markets.

Infrastructure for Promoting Advanced Biofuel Supply

Besides the small and nascent waste oils collection business, biofuel feedstocks are generally not produced or refined in Massachusetts. Without more capacity to grow or refine biofuel feedstock, the Commonwealth could face a situation with biofuels not unlike its current situation with regard to petroleum products—reliance on imports that drain rather than boost the state's economy.

UMass–Amherst, MassHighway, the Massachusetts Water Resources Authority and the City of Boston all use thousands of gallons of biodiesel blends from 5% to 20% in their fleets every year, with no adverse effects on their vehicles – resulting in significant reductions in carbon monoxide, particulate matter, and sulfates, as well as hydrocarbon and air toxics emissions.

—Massachusetts Leading by Example Program, EEA

Nationwide, there has been rapid expansion in refining capacity for both ethanol and biodiesel, primarily located close to corn and soy feedstocks. The U.S. overtook Brazil to become the world's leading ethanol producer in 2005, and production capacity has continued to grow rapidly, reaching an annual production level of 8.2 billion gallons in March 2008.[4] This growth has been driven by the Federal Renewable Fuels Standard (RFS), which requires 9 billion gallons annually in 2008. However, much of the additional 5.2 billion gallons of annual ethanol refining capacity under construction in the U.S. is on hold due to prices for feedstock and uncertainty around near-term ethanol demand above the mandated RFS.[5] A similar mismatch between planned refining capacity and expected production is evident for biodiesel, with 450 million gallons produced in 2007 but annual refining capacity now over 2.2 billion gallons, including plants under construction or on hold.[6]

Limited rail and truck capacity has also complicated the delivery of ethanol, contributing to regional ethanol supply shortages and price spikes between April and June 2006 when a national phaseout of the gasoline additive MTBE required replacement of roughly 10 percent of the gasoline blend with ethanol.[7] Feedstock and product transportation costs and bottlenecks remain problematic for the biofuel industry, leading many biofuel producers to explore the prospect of locating near a dedicated feedstock supply or large demand center to minimize transportation costs. In this context, several initiatives to site refining capacity in the Commonwealth have recently emerged and are seeking to navigate a balance between the supply and demand constraints in this expanding market.

Wholesale Biofuels Refining in Massachusetts

Currently, MBP Bioenergy is producing 1 million gallons of biodiesel annually from waste vegetable oil and animal fats in Massachusetts for use in its own vehicles and blended with fuel oil (B20) for sale to heating customers—and this business is expanding. The waste is collected within 80 miles of their production facility in Southeastern Massachusetts, and the product has been used for over three years for year-round heating and transportation without problems.

Three other companies are now in the final stages of development for new biofuel refining facilities:

- **Berkshire Biodiesel** is in the design and permitting phase of a 50 million gallon per year biodiesel production facility in Pittsfield that will use variable feedstocks, including animal fats and waste and virgin oils;
- **Northeast Biodiesel** is developing a 10 million gallon per year biodiesel production facility in Greenfield that uses locally-produced waste vegetable oil feedstock and that features a unique project financing strategy that partners consumers with government, foundation, and investor resources;
- **New Generation Biofuels** is in the final planning stage to construct a second-generation biofuel production facility in Quincy using virgin and waste oils. Intended to be used in pure form, rather than blended with petroleum fuels, the New Generation Biofuels product appears to have an improved greenhouse gas profile relative to diesel and biodiesel as a transportation fuel or heating oil substitute.

Public Safety Concerns

As Massachusetts and the U.S. as a whole move to include ethanol as a possible alternative to gasoline, a public safety concern has come to light regarding ethanol fires. Water does not extinguish ethanol fires and the foam that firefighters have used since the 1960s to fight gasoline fires does not work well either. The main concern is not cars powered by E10, but tanker trucks and rail cars that carry large quantities of higher ethanol content E85 fuel. During the last three months of 2007, there were three major ethanol fires in the U.S. involving derailed tanker cars: in Pennsylvania; a tanker truck crash in Missouri; and a train derailment in Ohio.[8]

Addressing this concern may require fire departments to invest in alcohol-resistant, polymer-based foam, which costs about 30% more than the standard foam currently used by fire departments. Additional safety training for firefighters and other emergency workers would also most likely be needed as E85 becomes more widely used.

Facilitating Biofuel Use in Massachusetts

Biofuels can be used in a variety of ways to reduce the use of petroleum fuels. Facilitating the use of biofuels requires a range of infrastructure investments to make biofuel products more available to consumers, as well as increased consumer demand to make biofuel production and distribution more economically viable.

Gasoline and Its Alternatives

The standard gasoline product sold in Massachusetts is E10, a blend of 10% ethanol and 90% gasoline. Used as a blending component, ethanol is displacing 5% to 6% of gasoline consumption nationwide. The federal Energy Information Administration projects that between now and 2030 most of the first 16 to 20 billion gallons of ethanol produced per year nationwide will be used in E10. With current domestic production at 8-9 billion gallons a year, and a maturing market for E10 that could reach 16 billions gallons in the next several years, there appears to be room for cellulosic and corn ethanol expansion in the U.S. at this 10% blend, which would require no further modification of existing terminals, retail pumps, or vehicles.[9]

In addition, a recent study by the state of Minnesota reports that blends as high as E20 can be safely used without vehicle modifications.[10] Raising blends to E20 will require further testing and a U.S. EPA waiver, and in Massachusetts may depend on whether this blend can satisfy reformulated gasoline standards. Within the U.S. market, E20 approval could expand the market potential for ethanol (both conventional and advanced) to around 30 billion gallons per year.

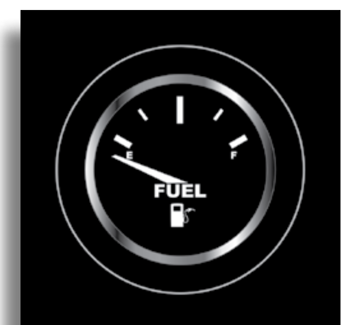
According to the U.S. Department of Energy: "The market potential for low to moderate biofuel blends (E10, B5, and B20) remains significantly larger than current production levels and will continue to absorb the biofuel supply for the foreseeable future. "[11]

Higher blends of ethanol—typically labeled as E85 (although blends may be as low as 60% ethanol)—would require changes to many older retail station pumps and storage tanks and, equally significant, require a larger fleet of flexible-fuel vehicles (FFVs) to make the retail infrastructure economically viable. In the future, ethanol may face competition from other gasoline-alternative advanced biofuels such as biobutanol and biomethanol. Biomethanol has similar infrastructure requirements as ethanol, so investment in flex-fuel vehicles would benefit either fuel. But biobutanol more closely resembles petroleum diesel in its fuel properties and may not require infrastructure changes if and when it becomes a commercially viable fuel.

E85 Retail Station Pumps

Currently, there is only one retail E85 pump in Massachusetts, installed in Chelsea in 2007 by Dennis K. Burke Fuel and expected to open for commercial operation in Spring 2008.

To date, preliminary research suggests that fuel-switching an existing gasoline storage tank and associated dispensing pumps to E85 is difficult to justify due to the low number of flex-fuel vehicles in Massachusetts (precise data is not available, but for the U.S. as a whole they constitute less than 3% of the total). While the infrastructure costs associated with fuel-switching for a modern retail gas station would not be significant, lost revenues from a gasoline tank and pumps converted to dispensing E85 involve uncertain risk.[12] The alternative is for retail stations to add fuel tanks and pumps to offer E85 without losing gasoline capacity. This requires significant capital outlays for new tanks and pumps, as well as the space and permits to expand.



Recent Energy Information Administration estimates for replacing one gasoline dispenser and retrofitting equipment to carry E85 at an existing fueling station range from $22,000 to $80,000 (2005 dollars), depending on the scale of the retrofit. Some newer fueling stations may be able to make less extensive upgrades, with costs ranging between $2,000 and $3,000. The installation cost of E85-compatible equipment for a new station is nearly identical to the cost of installing standard gasoline-only equipment, but the anticipated demand for an E-85 pump may well be lower given the limited number of vehicles able to use it, and price uncertainties.

The financial risk inherent in building new E85 infrastructure at the retail level has deterred investment in Massachusetts to date. Given this difficulty, the state could:

- support local and regional pilot development efforts of flex-fuel vehicle clusters to develop a critical mass of support for retail E85 infrastructure; and
- provide limited financial support for selected E85 fueling stations, such as at rest stops along the Mass Turnpike, at MassHighway facilities, along I-95/128, along I-93, or along other heavily-traveled roads.

Flex-fuel Vehicles

For biofuel blends substantially higher than the current E10 to become a market choice, consumers will need to have vehicles available to them that run on those fuels. Flex-fuel vehicles (FFVs) are cars and trucks capable of running on virtually any blend of ethanol and gasoline up to E85.[13] There are currently about 6.2 million flex-fuel vehicles operating in the U.S., 2% to 3% of the 228.5 million light-duty vehicles on the road.[14]

It is relatively inexpensive to manufacture vehicles as "flex-fuel," with additional costs averaging around $200 per vehicle. In Brazil, where sugarcane-based ethanol has been widely available for over a decade, most new cars are flex-fuel, with a wide variety of models on the market from manufacturers like Ford, GM, VW, Honda and Toyota. On the other hand, in the U.S. virtually all flex-fuel vehicles available for sale have large engines, making them relatively fuel inefficient models within their respective vehicle classes.

The reason for this appears to lie with the federal Corporate Average Fuel Economy (CAFE) vehicle efficiency standards. Both the existing and newly approved changes to the federal CAFE standards include a mileage credit for alternative-fuel vehicles. The result is that auto manufacturers get the greatest benefit from adding FFV capability to their most inefficient models. The U.S. Department of Energy's annual energy outlook report for 2007 comments on this regulatory effect: "Although the incremental cost for vehicle manufacturers to make some models E85-capable at the factory is low (about $200 per vehicle), virtually all FFVs built since 1992 have been produced for the sole purpose of acquiring CAFE credits."

The fuel inefficiency of vehicles selected by manufacturers for flex-fuel technology is compounded by reduced mileage from E85 fuel due to ethanol's lower energy content relative to gasoline. As a result, mileage of flex-fuel vehicles ranges from 10 to 16 miles per gallon (mpg) when running on E85 fuel, with an average of only 11.5 mpg for 2008 models, according to the U.S. EPA.[15] When running on gasoline, FFVs average about 16 mpg, about 20% below the average for all light-duty vehicles sold in Massachusetts.[16]

Federal changes to the CAFE regulations or a federal mandate to incorporate flex-fuel capability across the vehicle fleet are needed to get manufacturers to produce high-mileage flex-fuel cars in large volumes. Nonetheless, as there is no technological reason why flex-fuel capability should only be available in low mileage models, Massachusetts might encourage regional or federal consideration of mandates or incentives for car manufacturers to supply flex-fuel versions of their more fuel-efficient vehicle models.

Flex-fuel choices are further limited in Massachusetts because not all manufacturers are submitting their full line of flex-fuel models to the California Air Resources Board (CARB) On-Road New Vehicle & Engine Certification Program.[17] CARB certification is a requirement for sale of new on-road vehicles in Massachusetts and several other Northeast states. As a result, only a sub-set of flex-fuel models are available for sale in the state. Chevrolet, for instance, offers most of its flex-fuel models for sale in Massachusetts, but Ford makes only a limited number of its models available to Massachusetts car buyers.

Current policy for the state-owned auto fleet calls for purchasing fuel-efficient hybrid and regular gasoline vehicles. These policies could be amended to require these vehicles, including hybrids, to be flex-fuel when available, as long as they do not result in state agencies purchasing cars and light trucks that are less fuel efficient than others available in the relevant vehicle classes.

Diesel and Heating Oil Alternatives

As with E10 gasoline, biodiesel has achieved initial acceptance in low-percentage blends such as B5, B10, or B20. Most diesel engine manufacturers have now approved B5 usage in their engines, with higher blends under consideration for future certification. Notwithstanding engine warranties, it is generally accepted that most diesel engines are compatible with biodiesel blends in excess of B5.

Similarly, in the heating oil market, low biodiesel blends have been successfully used for several years, and heating oil boiler and burner manufacturers are increasingly open to the use of B5 and higher blends in their new and existing equipment. Since blends as low as B5 typically take on the performance characteristics of 95% petroleum-based fuel, performance issues are minimal.[18] Although lubrication is improved, the cleansing properties of biodiesel can lead to an initial build up of residues on filters from dirty tanks.

It is anticipated that low blends of biodiesel could be incorporated into the diesel and heating oil supply chain without significant retail infrastructure costs. But additional infrastructure would likely be needed to provide the heated storage and blending equipment required at the 13 regional terminals to provide statewide coverage. Based on estimated retrofit costs of around $500,000 per terminal, this work would cost up to $6.5 million over five years. The investment could be amortized over five or six years with terminal operators

In Spring 2008, Dennis K. Burke Fuel Company is expected to open the state's first retail E85 fuel pump in Chelsea.

—Dennis K. Burke

New York City estimates 13 million gallons of B20 have been used by over 9,000 heating customers with no storage problems or issues with their home heating systems.

making use of federal accelerated depreciation tax benefits to mitigate their costs. A state investment tax credit could also be considered to provide further mitigation of costs, if needed.

A move toward blends of biodiesel above B20 to offset petroleum could be more straightforward than ethanol, since diesel engines are generally more accommodating than gasoline engines and biodiesel fuel is also less corrosive than ethanol. It is unclear how much, if any, additional cost vehicle manufacturers would incur to produce engines certified for high biodiesel blends. Meeting air quality standards could require additional testing and modifications to vehicles, given that much of Massachusetts has not attained the Clean Air Act standards for nitrogen oxides (NOx). There are existing private fleets running on blends ranging from B20 to B100, but there is no significant retail sale of this fuel in Massachusetts.

In addition to the use of Number 2 oil for residential heat, there is a significant market for heavier Number 4 oil in industrial process heat and electric power generation. Number 4 oil is a blend of at least 20% Number 2 oil with heavy Number 6 residual oils. It would be relatively simple to substitute biodiesel for Number 2 oil in this blend to create a Number 4 blend of approximately 20% biodiesel and 80% Number 6 oil, as an effective way to offset significant petroleum use in oil boilers and burners. Boilers and burners are generally cleaner burning than diesel engines, and while this blend would require testing and MassDEP approval, only minor modifications (if any) to equipment are anticipated.

There is significant potential for second-generation biofuels such as bioemulsions, Fischer-Tropsch (FT) diesel, and dimethyl ether (DME) to displace diesel and Number 2 heating oil fuels while meeting Clean Air Act standards and greenhouse gas mitigation criteria for advanced biofuels. While these second-generation biofuels are not yet commercialized in the U.S., there are production facilities under development, such as New Generation Biofuels in Quincy, and several other next-generation biofuels under development around the world.[19]

New Generation Biofuels' fuel is made from an emulsion of renewable oils, alcohols, and water and is touted as an alternative to diesel fuel that may not require any modification to Number 2 oil burners or diesel engines. FT diesel is produced by gasifying feedstocks such as biomass or coal and then using the Fischer-Tropsch gas-to-liquids technology. FT diesel can be mixed with petroleum diesel at any blend percentage without the need for additional infrastructure.

While initially targeted primarily at the heating and power generation sector, these next-generation diesel alternatives could likely also meet the tighter performance specifications required to run existing diesel engines, with the potential of providing up to 100% displacement of petroleum diesel or heating oil fuels. For this reason, a statewide average approach to a diesel mandate, rather than a requirement for a percentage blend in every gallon sold, would create a more level playing field for alternatives to petroleum-based diesel and heating oils.

Because these fuels have diverse chemical compositions and are new to the market, there are no established quality standards to protect users, as have been developed over time for biodiesel. Proponents of these fuels design batches to either meet generic or individual customers' performance requirements or to meet original engine manufacturer standards. Quality of the fuel is then measured using standard analytical test methods for individual parameters. Emissions profiles from the combustion of these fuels will likely need to be determined to ensure air quality standards can be met.

Other Alternatives to Petroleum Fuels

Fuel Efficiency

The most effective and efficient way to reduce dependence on liquid fuels, including both petroleum and biofuels, is through improvements in vehicle fuel efficiency. Reduced petroleum use also results from shifts of freight from truck transportation to the more fuel-efficient modes of rail and barge. Significant efforts by long-haul trucking manufacturers and fleet owners to improve truck fuel efficiency are now under way. And, in contrast to the limited sales of current flex-fuel vehicles, new highly efficient hybrid car models have become popular with Massachusetts consumers, despite a significant cost premium.

Improved fuel efficiency in vehicle design is compatible with the use of alternative fuels, but the two have rarely been combined by car manufacturers to date. Clear policy incentives at the state and federal level will likely be needed to promote the complementary benefits of fuel economy and fuel flexibility.

Natural Gas and Propane

The primary direct competition to date for liquid petroleum fuels in the heating oil and power generation markets has come from natural gas and, to a lesser extent, propane. Natural gas is cost competitive, distributed easily by pipeline, and has largely displaced fuel oil for new installations in both the heating and power generation markets.

For transportation uses, both compressed natural gas and propane powered vehicles have been in use for some time. Both of these fuels have been heavily constrained by a lack of fueling infrastructure and by limited and fluctuating availability of these vehicles from vehicle manufacturers. In Massachusetts, these limitations have restricted compressed natural gas transportation use to geographically discreet fleets such as transit buses, state vehicles, and propane vehicles in pilot use. The withdrawal from production of compressed natural gas pick-up trucks and passenger cars by the major U.S. auto manufacturers in recent years suggests that only bus fleets will continue to use natural gas in significant volume.

Since most current hydrogen fuel is created by reforming natural gas, and a natural gas pipeline infrastructure is already in place, future hydrogen powered vehicles will likely be dependent on natural gas fuel in the near term. As a result, hydrogen fueling infrastructure will likely face constraints similar to or greater than compressed natural gas.

Electricity

Electric-powered and plug-in hybrid vehicles represent significant future alternatives to liquid transportation fuels. Electrification enables vehicles to make use of mature and highly efficient electric motor technology and the mature infrastructure of electricity distribution. To date, electric vehicles have had limited range and battery life, but this will become less of an issue as battery technology improves. Plug-in hybrid vehicles have no range limits, since they can run on liquid fuels, including biofuels, as well as electric batteries. However, plug-in hybrids do require a secure garaging location to recharge, preferably during off-peak night-time hours, which presents a problem for many urban households. Otherwise, the infrastructure and fuel supply for plug-in hybrids is already in place, and—unlike current flex-fuel vehicles—electric and hybrid vehicles are the most fuel-efficient in their vehicle classes.

Electric, hybrid, and plug-in hybrid vehicles are also available and well suited to heavy

In April 2008, the Executive Office of Energy and Environmental Affairs issued requests for proposals to retrofit state-owned gasoline hybrid vehicles with plug-in technology. The plug-in hybrids, which can achieve up to 100 miles per gallon and reduce greenhouse gas emissions even more than regular hybrids, are expected to be in use by various state agencies later this year.

duty vehicle classes such as buses and local delivery vehicles, where the efficiency of electric motors at low speeds is an excellent complement to internal combustion engines, which operate more efficiently at higher speeds. By transportation mode, the most rapid increase in the share of total energy demand for transportation is projected in the heavy vehicle travel sector, making medium and large freight trucks and buses a critical area for fuel efficiency innovation. [20]

Recommendations

Future solutions to petroleum dependence in Massachusetts are still emerging, as is the role that the biofuels industry will play among the several potential alternatives to oil. In advance, and in anticipation of a regional Low Carbon Fuel Standard, interim policies promoting biofuels can catalyze in-state production and infrastructure investments. The state should give equal consideration to infrastructure for all alternative fuels and other technologies that meet environmental standards and lead to reduced dependence on petroleum. These include:

1. Implement limited-cost investments in infrastructure for ethanol and biodiesel, subject to budget constraints, such as E85 stations along major state highway corridors, and possible assistance for storage and distribution of biodiesel.
2. Study the benefits and costs of measures to increase the share of flex-fuel vehicles in Massachusetts, including mandates and incentives. Such research should take into account both short- and long-term impacts on actual greenhouse gas emissions and other environmental concerns. Explore policies to induce automakers to provide more fuel-efficient flex-fuel vehicle models than are currently available. For its own fleet, the state should purchase flex-fuel vehicles that exceed the average CAFE standard mileage requirements for each vehicle class.
3. Subject to state budget constraints, provide incentives to encourage development of smaller regional biorefineries, especially for cellulosic biofuels, that utilize locally-available fuel including waste feedstocks.
4. Support pilot deployment of plug-in hybrid and all-electric vehicles (including flex-fuel plug-in hybrid vehicles) in light-duty, medium-duty, and heavy-duty vehicle classes.
5. Investigate the costs and benefits of incentives for additional heated storage tanks and blending infrastructure at regional diesel terminals.
6. Support rail freight infrastructure for biofuels as part of a broader policy of promoting rail over road freight transportation.

Chapter 5 Endnotes

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